REUSE OF CLAY AND CERAMIC GLAZE AT A BATHROOM FIXTURE MANUFACTURING PLANT

FEBRUARY 1994

Ontario

Ministry of
Environment
and Energy

ISBN 0-7778-1384-X

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PIBS 2855

REUSE OF CLAY AND CERAMIC GLAZE AT A BATHROOM FIXTURE MANUFACTURING PLANT

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DISCLAIMER

This report was prepared for the Ontario Ministry of Environment and Energy (formerly Ministry of the Environment) as part of a Ministry funded project. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of Environment and Energy, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. Note, all references to Ministry of the Environment in this report should read Ministry of Environment and Energy.

ABSTRACT

A wastewater treatment and solids recovery system was designed and constructed to reduce the solid waste volumes at American-Standard's Toronto plant, and to recycle a reusable, otherwise waste, resource.

Some delays in construction as well as difficulties in the wastewater treatment. solids recovery and solids recycle system startup were experienced. However, since the startup, some success has been achieved in the recovery and reuse of the two major solids streams: glaze and slip. These problems are being currently addressed.

The total annual payback from onsite resource recovery and recycle is estimated at $210,000.

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Section 1.0

INTRODUCTION

American-Standard owns and operates a bathroom fixtures manufacturing plant in Metropolitan Toronto. In 1989 this plant generated over 1500 tons of solid waste which was hauled to the Metro Landfills at considerable cost to American-Standard. In addition, the sludge storage capacity in the plant was very low and could not be increased due to site restrictions, necessitating higher frequency of sludge transportation to the disposal sites.

American-Standard in consultation with their Environmental Consultants, CH2M HILL ENGINEERING LTD. of Waterloo, Ontario, conducted a study for evaluating the feasibility of recovering and recycling of its solid wastes. The study concluded that the waste streams generated in American-Standard represented a very good potential for materials recovery and recycle. It was determined that solids recycle was both technically feasible and environmentally and economically desirable.

For this reason, in 1988 an application to solicit funds from the MOE's 3Rs financial assistance program was prepared by CH2M HILL on behalf of American-Standard. This program provided incentives to industry to recycle materials. The American-Standard proposal was accepted by MOE and considerable funding was made available to American-Standard, which helped to accelerate the implementation of the materials recovery program.

The wastewater treatment and solids recovery and recycle system at American-Standard was constructed in 1989. The wastewater treatment and solids recovery system went into operation in the same year. The partial startup of the recycle system occurred in April 1991 and by July 1991 the recycle system was fully operational.

Section 2.0

WASTEWATER TREATMENT AND SOLIDS RECOVERY AND RECYCLE SYSTEM

2.1 GENERAL

Several process wastewater streams originate from the production operations. For treatment and recovery purposes, they are divided into two main groups: glaze wastewater, originating in automatic and manual spraying operations; and slip wastewater from a finishing machine, finishing booths, a wet dust collector, funnel washing and other sources. All of these wastewaters were previously discharged with (glaze) or without (slip) treatment to the Metro Toronto combined sanitary storm sewer. In addition to this, large quantities of sludge were generated from clarification and settling operations which had to be transported to local or secure landfills for disposal at considerable cost.

2.2 WASTEWATER FLOW AND CHARACTERIZATION

Wastewater characterization and treatability studies for the American-Standard's Toronto Plant were carried out by CH2M HILL in 1988. Table 1 lists the contribution of each unit process to the total plant flow. Flows are given on both daily and weekly basis.

Table 1
Contribution of Unit Processes to the Total Plant Flow

Unit Process	Daily Flow*	Days of Operation per Week	Total Weekly Flow*
Bank units	5,000 (P.D.)	6	30,000
Funnel wash	5,000 (P.D.)	6	30,000
Slip house	1,950 (P.D.)	6	11,700
Wet dust collector	2,000 (P.W.)	7	14,000
Plaster shop	960 (P.D.)	5	4,800
Finishing booths	15,000 (C)	7	105,000
Finishing machine	6,850 (C)	7	47,950
Glaze Shop	400 (P.D.)	7	2,800
Spray Machine #1	2,500 (P.D.)	7	17,500
Spray Machine #2	2,500 (P.D.)	7	17,500
Spray booths	2,500 (P.D.)	7	17,500
Plating shop	3,800 (C)	5	19,000
Total			346,450
Average Daily Flow			49,492

*All flows in USgpm
P.D. = Periodic daily
C = Continuous

Total suspended solids (TSS) concentrations and pH for various waste streams and the composite sample are given in Table 2.

Table 2 Total Suspended Solids and pH Values for Various Process Wastewater Streams at American-Standard's Toronto Plant			
Sample	Process Stream (see Figure 3)	TSS (mg/L)	pH
1	Plating	3	7.7
2	Plaster pit effluent	39	7.0
3	Slip pit effluent	21,550	8.1
4	Lamella effluent	25	7.5
5	Rotunda pit effluent	1,820	7.8
6	Spray machines & booths	3,850	8.2
7	Finishing booths	473	7.6
8	Glaze shop	1,781	7.2
9	Composite sample	2,500	7.8

All pH values were within the allowable range (6-10.5). TSS concentration of some waste streams exceeded the combined sewer use by-law limit.

2.3 WASTEWATER TREATMENT AND SOLIDS RECOVERY SYSTEM PROCESS DESCRIPTION

The wastewater treatment system is divided into two major functions: the Glaze and the Slip Wastewater ad solids recovery Systems. In addition to the process diagrams provided in the text, larger process and instrumentation diagrams are also attached in Appendix B.

The Glaze Wastewater Treatment and Solids Recovery System (see Figure 1) collects glaze wastewater from sumps located at Spray Machines No. 1. No. 2 and at the Spray Booths. The wastewater is then pumped into one of the four Glaze Recovery Tanks. By means of a selector switch, the operation staff can select which Glaze Recovery Tank the wastewater will go to, depending on what colour of glaze is being sprayed. The segregation of glaze colours permits recovery and reuse of glaze. Each of the three wastewater sumps has a dedicated line to the Glaze Recovery Tanks so that each spray operation can spray a different colour without having to mix colours.

Before the wastewater enters the Glaze Recovery Tanks, an appropriate dosage of a coagulating cationic polymer is automatically applied by means of in-line injection. Polymer addition encourages flocculation and speeds clarification which takes place in the Glaze Recovery Tanks. Supernatant from these tanks is pumped to the Lamella clarifier where a flocculating agent (anionic polymer) is added and final separation of suspended solids from the liquid is accomplished. Clarified effluent from the Lamella clarifier flows by gravity to the wastewater effluent tank and then to the sanitary sewer and the sludge is wasted periodically to Tank A (others tank).

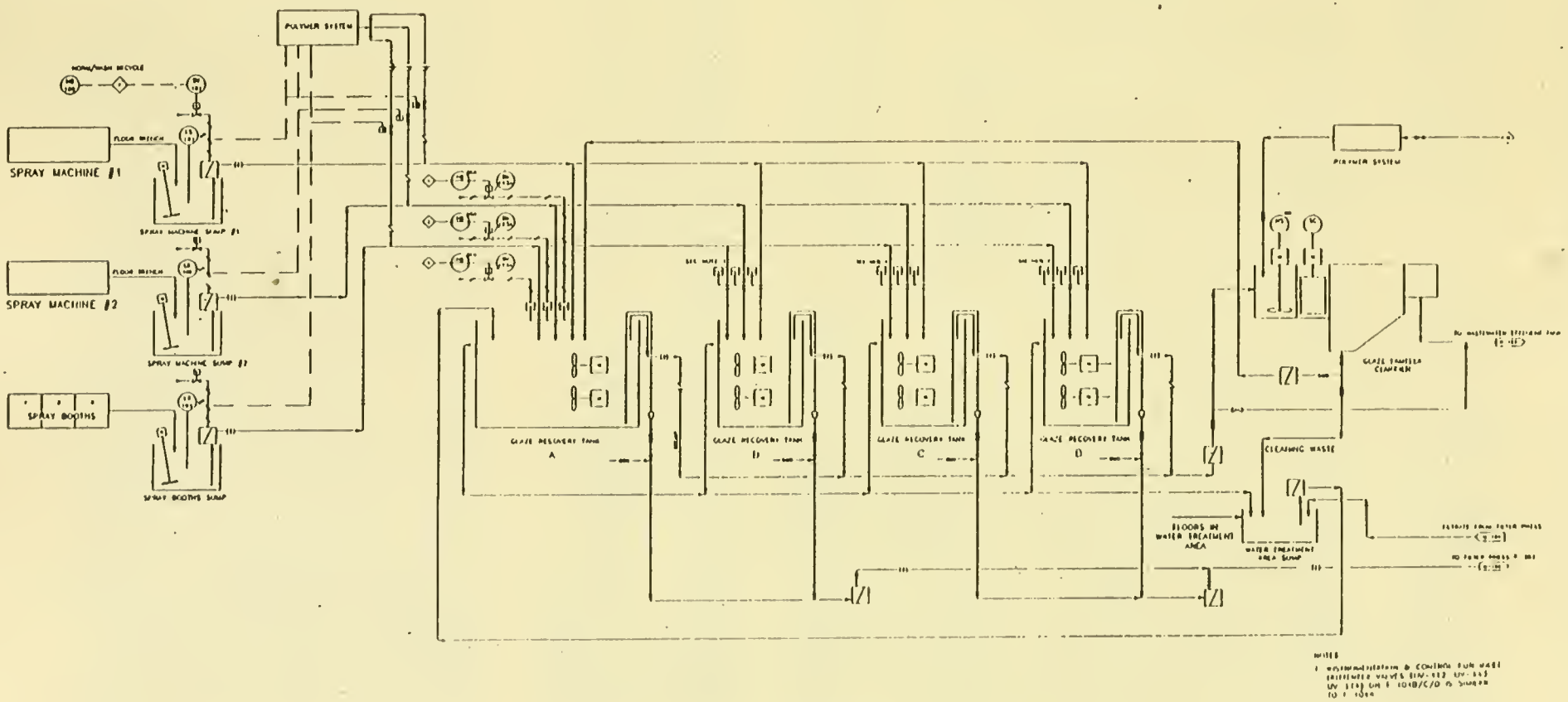


FIGURE 1

AMERICAN STANDARD
WASTEWATER TREATMENT FACILITIES

GLAZE RECOVERY & CLEANER
PROCESS
FLOW DIAGRAM

Settled sludge from the Glaze Recovery Tanks is pumped to the recessed plate filter press for dewatering (see Figure 3). Filtrate is directed back to the glaze system and the filter cake can be recycled or disposed of (see Section 2.4).

The Slip Wastewater Treatment and Solids Recovery System (see Figure 2) collects slip wastewater from various locations in the plant. All streams are combined in the old Lamella pit and after equalization directed to a Lamella clarifier for separation of suspended solids. The wastewater is dosed with polymer as it enters the clarifier. The polymer feed rates can be paced to the flow of wastewater by way of a feedback control mechanism in the flowmeter. Slip sludge is pumped to the Slip Sludge Tank. Clarified effluent overflows to the wastewater effluent tank. A turbidity measurement is made on the combined flow, and an alarm will sound at the main electrical panel if the combined effluents from the two clarifiers is high in suspended solids (i.e. higher than the upper limit programmed into the turbidity meter).

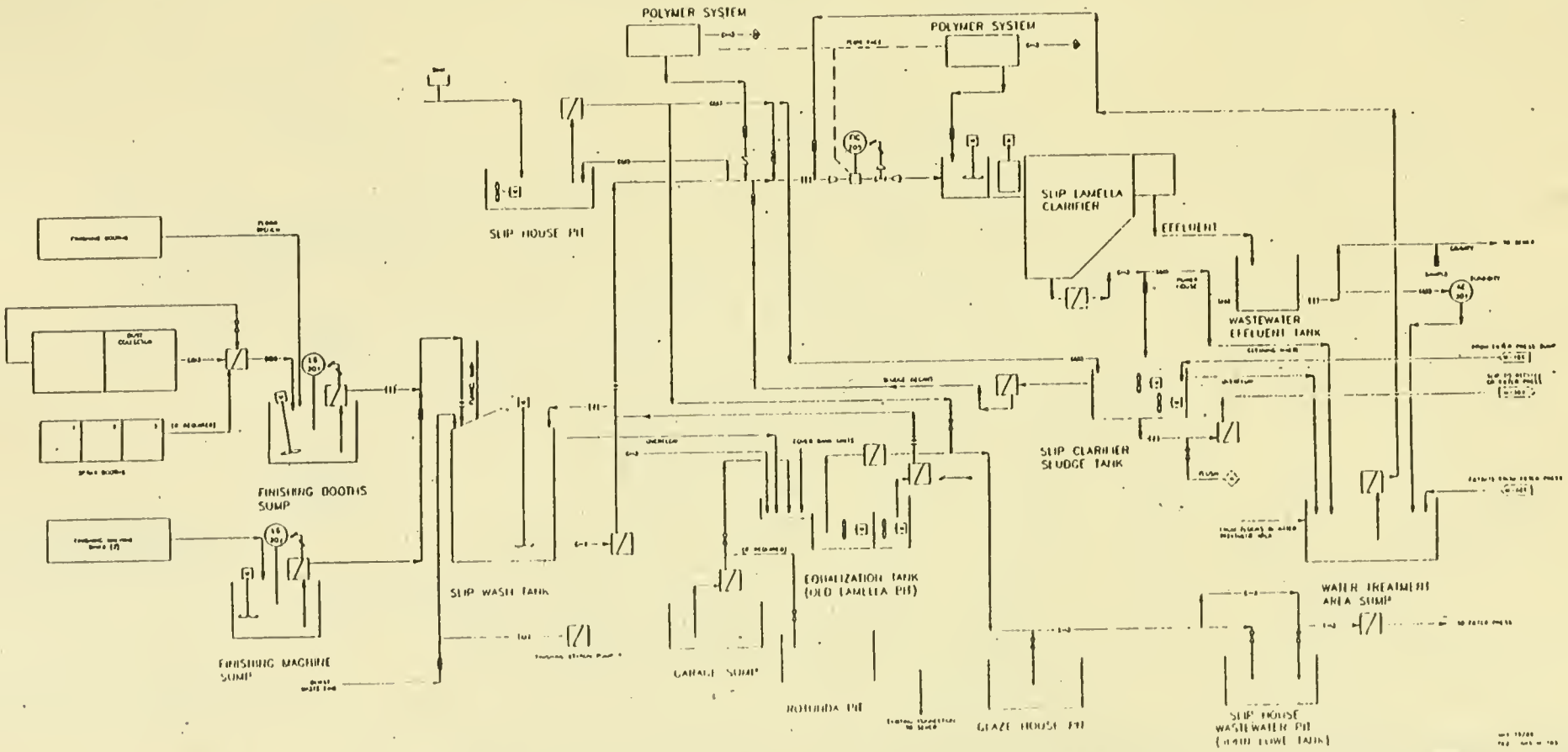
Supernatant from the settled Slip Sludge Tank is circulated back to the Lamella and bottom sludge pumped to the filter press (see Figure 3 The filter cake can be disposed of or recycled and filtrate is directed to the wastewater effluent tank and then to the sanitary sewer.

The option exists to pump thickened virgin slip from the old Lamella pit directly to the filter press. The resulting filter cake can then be recycled without concerns for the effects of polymers on the finished products.

2.4 SOLIDS RECYCLE SYSTEM PROCESS DESCRIPTION

The purpose of the solids recycle system is to recycle and reuse clay slip and ceramic glaze that has been previously lost to the wastewater. The intent is to reduce production costs and decrease the amount of waste material that is currently shipped offsite for disposal.

Solids contained in the wastewater streams from the production processes and recovered in the recovery tanks and Lamella clarifiers, are dewatered in a 1 metre filter press (see Figure 3). This is a batch operation. After dewatering is completed the operator must decide whether the filter cake is suitable for reclaim. If the filter cake is contaminated with impurities, it cannot be readily recycled and the material will be transported by a screw conveyor to a storage bin located outside the building for subsequent shipment and disposal offsite. Reusable slip or glaze material will be transferred via the reversing screw conveyor into the Cowles Disperser tank where water is added and the filter cake refluidized into a pumpable slurry. This batch process is completed within 2-3 minutes. The contents of the disperser tank are then fed via an air operated double diaphragm pump through Sweco vibrating screen (where oversized solids are rejected) to magnetic separators (to remove ferrous based contaminants) and the reclaimed product is directed to the appropriate holding tank.



DKC

GEB

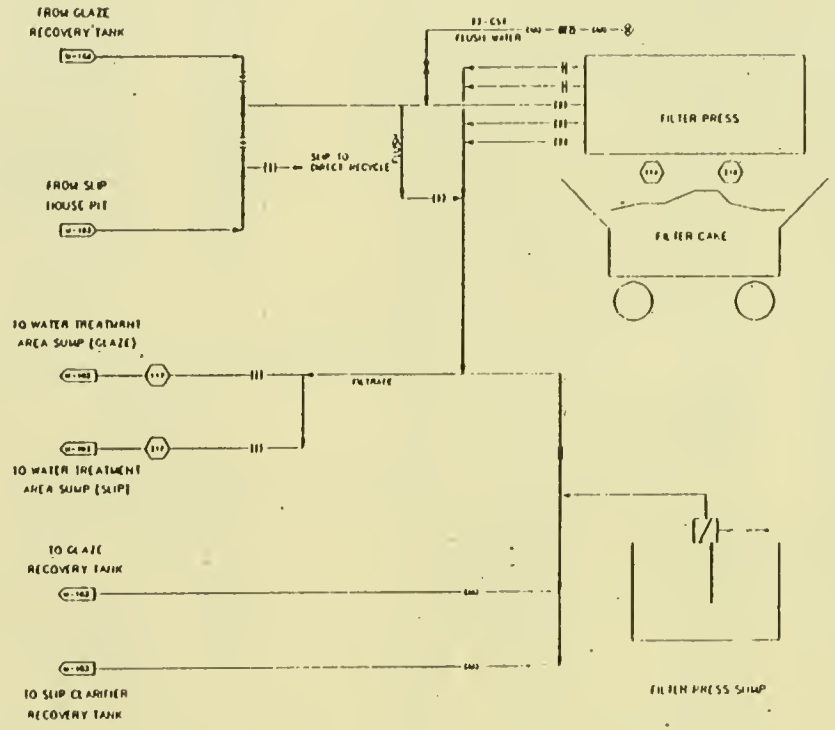
DKC

DRAWING STATUS

ISSUED FOR

AMERICAN STANDARD
WASTEWATER TREATMENT FACILITIES

SLIP WASTEWATER TREATMENT
PROCESS FLOW DIAGRAM



DKG

GEB

DKG

FIGURE 3

AMERICAN STANDARD
WASTEWATER TREATMENT FACILITIES

FILTER PRESS
PROCESS & INSTRUMENTATION
DIAGRAM

M-402 - M-405
GLAZE TANK MIXERS

M-406
SLIP TANK MIXER

M-407
VIRGIN SLIP TANK MIXER

T-401
DISPERSION TANK

T-402
NO. 1 (WHITE) GLAZE TANK

T-403
NO. 2 (BONE) GLAZE TANK

T-404
NO. 3 (GRAY) GLAZE TANK

T-405
MIXED GLAZE TANK

T-406
SLIP TANK

T-407
VIRGIN SLIP TANK

P-401, - P-407
TRANSFER PUMPS

C-401
SCREW CONVEYOR

M-401
COWLES DISPERSER

#S-401/#S-402
SWECO SCREENS

A-401, A-402, A-403, A-404
MAGNETIC SEPARATORS

H-401
WASTE FILTERCAKE HOPPER

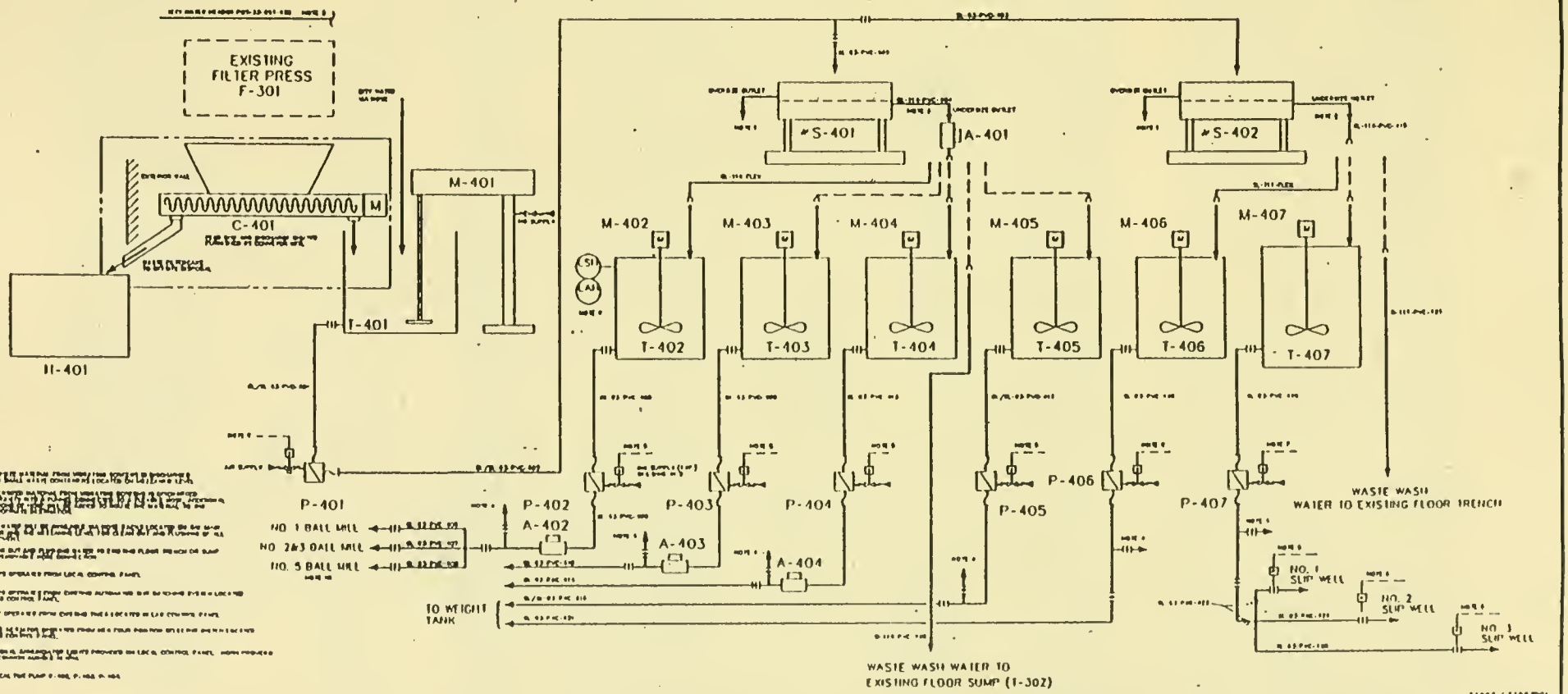


Figure 4

AMERICAN STANDARD
SLIP AND GLAZE RECYCLING
PROCESS
AND
INSTRUMENTATION

The system consists of six holding or storage tanks each dedicated to a specific material. There are four glaze storage tanks designated as white, bone, grey and mixed coloured glaze and two slip tanks designated virgin or polymer free slip and slip with polymer added. The four glaze tanks and the virgin slip tank have a nominal capacity of approximately 7 m^3 and are constructed from fibreglass reinforced plastic (FRP), while the larger 16.7 m^3 polymer-added slip tank is constructed of 304 stainless steel. Each tank is equipped with a 7.5 - 15 HP low speed (approximately 40 rpm) agitator with dual flat paddle type impellers to maintain a homogeneous mixture and to prevent solids from settling out of suspension. These mixers are in continuous operation when there is fluid in the tanks.

Prior to reuse all reclaimed material must pass QA/QC testing by production staff. If this testing determines that the material is unsuitable for reuse, the contents of the affected storage tank must be pumped back to the filter press feed tank to be dewatered again and sent offsite for disposal.

When production calls for reclaimed material, the operator activates the appropriate air operated diaphragm pump and transfers the required amount to one of the following destinations:

a) glaze to the ball mills
b) slip to the slip tanks
c) slip and mixed coloured glaze to the weigh pod

The automated slip batch makeup system which uses the weigh pod has been reprogrammed to include new recipes which include reclaimed slip and mixed colour glaze. When recipes using the reclaimed material are ordered, the reclaimed material will be transferred until the weight requirement demanded by the recipe is met and then transfer will stop.

2.5 WASTEWATER TREATMENT AND SOLIDS RECOVERY UNIT PROCESSES

2.5.1 GLAZE WASTEWATER TREATMENT AND SOLIDS RECOVERY SYSTEM

WASTEWATER COLLECTION AND PUMPING SYSTEM

1. **Spray Machine No. 1 Pumping System**
   Sump T-101

   Function: Collects glaze wastewater from spray Machine No. 1 area.

   Description: Volume 3.2 m^3. Retention time 8 h; equipped with tank washing nozzle connected to city water supply through backflow preventer

and operated with manual globe valve. This sump is to be flushed before there is a colour change.

Mixer U-104

Function: Keeps solid particles in suspension to prevent solids build-up at the bottom of the tank and suction line clogging. Equipped with on/off locally mounted switch.

Sump Pump P-101

Function: Pumps glaze wastewater from sump T-101 to one of four Glaze Recovery Tanks.

Description: Air operated double diaphragm pump manufactured by ITT Marlow, model 2" A.O.D.; normal pumping rate 14 m^3/h.

Operation of Spray Machine No. 1 Pumping System

A locally mounted selector switch enables an operator to select which of the four Glaze Recovery Tanks the wastewater will go to, depending on what colour of glaze is being sprayed. When the switch HS-100 labelled "normal/wash recycle" is in "normal" position, the wastewater is pumped to the selected Glaze Recovery Tank and only one of the air operated control valves (UV 112 A, B, C, D) at the end of the discharge line can be open at one time. This is controlled by the PLC program. The pump is turned on and off by the pneumatic level sensor installed in the sump 300 mm from the bottom. When all of the wastewater is to be pumped out of the sump (e.g. cleaning operations), the level sensor must be bypassed by using the 3-way manual valve on the air supply line (with switch HS-100 in "normal" position). In the "wash recycle" position, the discharge valves (tagged UV 112, A,B,C,D) are closed and wastewater cannot be pumped to the Glaze Recovery Tanks. Instead, it can be recycled to wash down the spray machine and floor trenches. This procedure is required each time the glaze colour is changed.

2. Spray Machine No. 2 Pumping System

Sump T-102

Function: Collects glaze wastewater from Spray Machine No. 2 area.

Description: Volume 9.1 m^3; retention time 23 h; equipped with tank washing nozzle connected to the city water supply through a backflow preventer and operated with a manual globe valve. This sump is to be flushed before there is a colour change.

Mixer

Function: Keeps solid particles in suspension to prevent solids build-up at the bottom of the tank and suction line clogging. Equipped with a locally mounted on/off switch.

Sump Pump P-102

Function: Pumps glaze wastewater from sump T-102 to one of four Glaze Recovery Tanks.

Description: Air operated double diaphragm pump; manufactured by Wilden, model 2" A.O.D.; normal pumping rate 14 m^3/h.

Operation of Spray Machine No. 2 Pumping System

Operation procedure is the same as for Spray Machine No. 1 Pumping System.

3. **Spray Booths Pumping System**

Sump T-103

Function: Collects glaze wastewater from Spray Booths area.

Description: Volume 2.3 m^3. Retention time 2.2 h; equipped with a tank washing nozzle connected to the city water supply through a backflow preventer and operated with a manual globe valve. This sump is to be flushed before there is a colour change.

Mixer

Function: Keeps solid particles in suspension to prevent solids build-up at the bottom of the tank and suction line clogging; equipped with a locally mounted on/off switch.

Sump Pump P-103

Function: Pumps glaze wastewater from sump T-103 to one of four Glaze Recovery Tanks.

Description: Air operated double diaphragm pump; manufactured by Wilden, model 2" A.O.D.; normal pumping rate 14 m^3/h.

Operation of Spray Booths Pumping System

Operation of Spray Booths Pumping System is the same as Spray Machine No. 1 and No.2 Pumping Systems.

4. Glaze Shop Sump Pumping System

Sump T-105

Function: Collects glaze wastewater from Glaze Shop area.

Sump Pump P-104

Function: Pumps glaze wastewater from sump T-105 to Glaze Recovery Tank T-104A.

Description: Air operated double diaphragm pump. Manufactured by ITT Marlow model 1.5 A.O.D.; normal pumping rate 7 m^3/h. This sump is to be flushed before there is a colour change.

Mixer

Function: Keeps solid particles in suspension to prevent solids build-up at the bottom of the tank and suction line clogging; equipped with a locally mounted on/off switch.

Operation of Glaze Shop Sump Pumping System

Wastewater is pumped intermittently to Glaze Recovery Tank T-104A. A pneumatic level sensor installed in the sump 300 mm from the bottom turns the pump on and off. When the sump needs to be emptied completely, the level sensor must be bypassed by using the 2-way manual valve on the air line.

GLAZE RECOVERY TANKS

The purpose of the four Glaze Recovery Tanks T-104 A,B,C, and D is to receive glaze wastewater from various locations in the plant, settle out suspended glaze solids and segregate glaze colours to permit recovery and reuse of glaze.

1. Tank T-104 A (Others Tank)

Function: To receive glaze wastewater from the following sources:

- Sump T-101 at Spray Machine No. 1
- Sump T-102 at Spray Machine No. 2
- Sump T-103 at Spray Booths

- Glaze Shop Sump T-105
- Glaze Lamella Sump T-106
- Sludge blowdown from Lamella Clarifier

This tank has been designated to receive glaze wastewater, which is not going to be segregated by colours for recycle. It is equipped with two submersible mixers and an ultrasonic level measurement instrument. The purpose of this tank is to settle out suspended glaze solids and subsequently enable pumping the bottom sludge to the filter press and supernatant to the Glaze Lamella Clarifier. Capacity of the tank is 40 m^3.

Operation: All wastewater streams mentioned above are mixed in Tank T-104-A. Polymer is added through in-line injection to the streams coming from the spray machines and the spray booths to coagulate the suspended solids particles and allow them to settle out. To prevent solidifying at the bottom of the tank, two submersible mixers are turned periodically. It should be determined experimentally how frequently, and for how long mixing, which is controlled by a PLC program must be applied to prevent the glaze from solidifying.

In the first phase of the filter pressing operation, the mixers are turned off and the glaze material allowed to settle. The supernatant is then decanted to the wastewater effluent tank if it is determined, using the Hach turbidimeter, to be within the by-law limits, or if out of compliance, directed to the Lamella clarifier for polishing. After decanting, the mixer is turned on to keep the thickened sludge fluid. Settled solids are pumped to the filter press by the pump P-108A which is controlled manually using a hand switch located at the filter press.

When required, supernatant from the tank is pumped to the glaze Lamella clarifier at a constant rate (max. 10 gpm). If the wastewater level in the tank drops close to the end of the suction pipe (low-level condition) the ultrasonic level detector will close valve UV116a, which is installed on the suction line, and pumping stops. When a high-level condition is indicated by the ultrasonic level detector, an alarm will sound at the main electrical panel. Overflow from this tank is directed to Glaze Lamella Sump T-106.

2. Tanks T-104B, T-104C, T-104D

Function: To receive glaze wastewater from the following sources:

- Sump T-101 at Spray Machine No. 1
- Sump T-102 at Spray Machine No. 2
- Sump T-103 at Spray Booths

These three tanks have been designated to receive glaze wastewater segregated by colours. Operators of the Spray Machines and Spray Booths are responsible for directing the flow to the appropriate tank by means of a selector switch (depending on what colour of glaze is being sprayed).

The tanks are also equipped with submersible mixers as shown on the flow diagram and ultrasonic level measurement devices. Tank capacity: 37 m^3 each.

Operation: These three tanks operate in the same manner as has been described for tank T-104A. Settled glaze solids are pumped to the filter press by pumps P-108A and P-108B. The operator chooses which tank the settled solids will be pumped from and sets manually operated valves on the suction lines accordingly. When colours are changed, discharge and suction lines from the tanks to the filter press which are to be flushed with city water are connected to the pumping system.

3. Pumps installed at the Glaze Recovery Tanks

- Filter Press Pumps P-108A and P-108B transfer bottom sludge from Glaze Recovery Tanks to the Filter Press.

  Manufactured by ITT Marlow model 2" A.O.D. Normal pumping rate - 8 m^3/h.

4. Submersible Mixers

Function: To evenly distribute polymer in the liquid and to keep solids particles in suspension to prevent solid build-up at the bottom of the tank and clogging of sludge suction line.

Operation: Each of the Glaze Recovery Tanks is equipped with two submersible mixers manufactured by Flygt. The mixers should work intermittently to prevent the sludge from solidifying and also to minimize shearing of the floc. Before filter pressing, they must be turned off for some time to enable suspended solids to settle. The

most efficient procedure and timing will be established during the operation by the operator.

GLAZE LAMELLA CLARIFIER CL-101

Function: To settle out suspended solids from the effluent of the Glaze Recovery Tanks.

Operation: The Lamella Gravity Settler is a simple unit to operate. The only item requiring operator attention is the sludge withdrawal rate. A continuous sludge withdrawal has been employed by means of a progressing cavity pump discharging into Glaze Recovery Tank - 104-A called "others tank". The proper sludge withdrawal rate must be established and the sludge blanket level periodically checked using sample taps located at the side of the sludge hopper.

Washwater from the clarifier area drains to the Glaze Lamella Sump T-106 and is transferred by a pump to the "others tank".

2.5.2 SLIP WASTEWATER TREATMENT AND SOLIDS RECOVERY SYSTEM

The Slip Wastewater Treatment and Solids Recovery System treats liquid wastes originating in the finishing booths, finishing machine wet dust collector, funnel wash, bank units, slip house, and other areas in the plant.

Combined wastewater from all of these sources is finally directed to the Slip Lamella Clarifier where, after addition of polymers, suspended slip solids are settled out and clarified effluent is discharged to the sewer. The sludge resulting from this operation is subsequently filter pressed and reused or disposed. Filtrate is recycled back to the system.

SLIP WASTEWATER COLLECTION AND PUMPING SYSTEM

1. Slip Wash Tank T-104

Function: To receive wastewater from the following sources:

- Finishing Machine Sump T-202
- Finishing Booths Sump T-201
- Dorst Waste Line
- Funnel Wash

Slip Wash Tank also acts as a storage and preliminary equalization facility.

Operation: Streams coming into the tank differ substantially in concentration of suspended solids and daily flow pattern. This necessitates an efficient equalization of both flow and concentration for the successful performance of the Lamella clarifier. The Slip Wash Tank provides preliminary equalization only. It is equipped with a top mounted mixer and also, at low-level conditions, additional mixing is applied by recycling tank effluent, pumped normally to the Old Lamella Pit, back to the tank. This is accomplished automatically by means of a level switch and an air operated control valve. Effluent from the tank overflows to the Old Lamella Pit.

Tank capacity: 26.5 m^3.

2. Old Lamella Pit T-206

Function: Storage, equalization, and settling. It receives slip wastewater from:

- Slip Wash Tank T-204
- Garage Pit T-208
- Cover Bank Units

Operation: The Old Lamella Pit has a volume of 51.1 m^3. The effluent is pumped directly to the Slip Lamella Clarifier by 3" AOD pump P-209 which is controlled by a pneumatic level switch.

To decrease loading of suspended solids on the Lamella clarifier, the settled sludge from the bottom of the pit can be pumped out of Stage 1 directly to the filter press. Two submersible mixers installed in the Old Lamella Pit prevent the sludge from solidifying. Stage 1 allows sludge to settle out and is mixed only when filter pressing. Stage 2 remains mixed to allow continuous feed to the slip Lamella clarifier.

3. Dust Collector Wastes

Liquid wastes from the Dust Collector are pumped out periodically and discharged to the finishing booth sump.

4. Slip House Pit T-203

Function: Slip House Pit collects liquid wastes from the Slip House Area and sink SK-2E.

Operation: The Slip House Pit is equipped with a Flygt submersible mixer and pump P-205, which is controlled by a level switch. The dis-

charge line from the pump is connected to the Slip Waste Tank. This enables bypassing the Slip Clarifier when the concentration of suspended solids in the content of Slip House Pit is high enough for filter pressing. This piping arrangement also enables the direct entrance of combined flow from Old Lamella Pit, Dust Collector, and Slip House Pit to the Slip Sludge Tank T-205, bypassing the Slip Clarifier.

MAGNETIC FLOWMETER AND CONTROL VALVE

Before combined slip wastewater enters the flash mixing chamber of the Slip Clarifier, it passes through a flow control system consisting of a magnetic flowmeter and an air operated control valve. The purpose of this system is to maintain constant wastewater flow, which is essential for proper operation of the clarifier, and to pace polymer feed.

The flowmeter produces a 4-20 mA electrical signal which controls the polymer pumps. This signal is also converted by a transducer to a 3-15 PSI pneumatic signal to control the air operated valve on the slip wastewater line. A controller located at the main electrical panel allows a desired flow rate to be set and displays actual flow rate in US gal/min.

SLIP LAMELLA CLARIFIER CL-201

Function: To settle out suspended solids from slip wastewater.

Operation: The most important factor governing the successful operation of the Lamella clarifier is a proper sludge withdrawal rate. Continuous sludge withdrawal has been found suitable for slip sludge. The proper rate must be experimentally determined by performing the test described in detail in Axel Johnson's Operation Manual. Sludge withdrawal is carried out by means of a progressing cavity pump which discharges into the Slip Sludge Tank T-205.

SLIP SLUDGE TANK T-205

Function: Receives slip sludge from the Slip Clarifier, settles out suspended solids and enables the sludge to be pumped for filter pressing.

Operation: The Slip Sludge Tank T-205 continuously receives sludge from the Slip Clarifier. It is equipped with two submersible mixers to prevent solids build-up at the bottom of the tank. The mixers. controlled by the PLC program, should work intermittently. However, shortly before filter pressing they must be turned off using a

hand switch overriding the PLC program to let the solids settle. Supernatant from this tank should be recycled to the Slip Clarifier feed line by pump P-212.

An ultrasonic level switch will stop this pump if the wastewater level is close to the end of the suction pipe and activates an alarm at high level conditions.

Overflow from this tank is directed to the sump T-209 which also collects washing wastes from the Slip Clarifier.

POLYMER FEED SYSTEM

The following have been found effective in coagulation of suspended solids for slip and glaze wastewater:

1. cationic polymer, liquid form, density 1.16

2. anionic polymer, liquid form, density 1.06

Dosage of polymers depends on the concentration of suspended solids in treated wastewater. It must be experimentally determined and periodically checked using the procedure described in Axel Johnson's Lamella clarifier Manual or as outlined by the polymer manufactures' representatives.

In the glaze wastewater system, coagulating polymer is applied through injection ports into the lines coming from Spray Machine No. 1. Spray Machine No. 2 and the Spray Booths. The PLC program activates the polymer dosing system when a flow of wastewater in the lines occurs and shuts off if there is no flow.

Flocculating polymer is applied into the flocculator of the Glaze Lamella clarifier. Coagulant is applied into the decant pump discharge line.

In the slip wastewater, both coagulant and flocculant are applied to the flash mixing chamber of the Slip Clarifier.

Four identical Polyblend units have been installed to meter, dilute and feed liquid polymer and water. Each unit consists of a diaphragm type metering pump and a mixing chamber. The following is a method of metering pump adjustment to get desired polymer dosage. This method has not been described in the manufacturer's manual.

Metering pump capacity can be controlled by adjusting:

1. frequency of stroke expressed in percent of frequency at full pump capacity (1 USgph)

2. length of stroke expressed in percent of full stroke

Formulas for calculating frequency of stroke at given polymer dosage:

D - desired concentration (dosage) of polymer in wastewater, mg/L
Fr - frequency of stroke expressed in percent of frequency at full capacity
F - flow rate of wastewater USgpm
S - length of stroke expressed in percent of full stroke

For Coagulant

Fr = F•D•0.0517% at 100% stroke length

For Flocculant

Fr = F•D•0.00566% at 100% stroke length

Formulas for calculating dosage of polymer at given frequency and length of stroke:

For Coagulant

$$D=\frac{Fr\bullet S}{F}\times 1.93 mg/L$$

For Flocculant

$$D=\frac{Fr\bullet S}{F}\times 1.77 mg/L$$

The flow rate of dilution water should be high enough to provide concentrations of polymer in the mixing chamber of .1 to .5 percent.

For further information regarding operation and maintenance of the Polyblend unit, refer to the manufacturer's manual.

TURBIDITY METER

Part of the flow from observation tank T-301 to the sewer is diverted to the turbidity meter for measurement of suspended solid content. Sample turbidity is displayed continually by the four digit LED display during normal operation in NTU units.

The adjustable high turbidity alarm should be set at 100 mg/L suspended solids.

This instrument should be set up and calibrated by a Journeyman Instrument Mechanic or a factory technician who is approved by and represents the instrument manufacturer.

2.6 SLIP AND GLAZE RECOVERED SOLIDS RECYCLE UNIT PROCESSES

1. Filter Press F-301

Function: To receive recovered slip and glaze solids from the wastewater treatment and solids recovery system.

Operation: The press is a one meter recessed plate filter press (Capacity: 1000 gallon/run). Dewatered dry cake is 70 percent TS. After dewatering is completed, the operator decides whether the filter cake is suitable for reclaim.

2. Filter Cake Hopper H-401

Function: To direct dewatered solids into the Conveyor.

Operation: This 5 m^3 hopper is made of mild steel and diverts the dewatered slip and glaze solids into the screw conveyor.

3. Reversible Screw Conveyor C-401

Function: The Screw Conveyor is used to transfer dry cake to either a storage bin, located outside the building for offsite disposal, or into the Cowles disperser tank for recycle and reuse.

Operation: The Screw Conveyor is equipped with a 7.5 HP (5.6 KW) motor. The conveyor is reversible and can deliver the reclaimed solids for offsite disposal or onsite recycle.

4. Disperser Tank T-401

Function: To receive dewatered cake from filter press F-301 via screw conveyor C-401.

Operation: This tank is 2.3 m^3 in capacity and is made of 304 Stainless Steel. The tank is normally left empty. The Filter Cake is transferred to this tank

only when the disperser is required to be used for refluidizing the dewatered cake before recycle.

5. Cowles Disperser M-401

Function: To refluidize dewatered cake into a pumpable slurry.

Operation: Reusable slip and glaze material is transferred via the reversible screw conveyor into the Cowles disperser tank T-401, where water is added and the filter cake is refluidized for subsequent downstream reuse. This process is completed within 2-3 minutes.

The Cowles disperser is equipped with a 50 HP (37.3 kw) motor.

6. Sludge Pump P-401

Function: To transfer refluidized sludge from the Cowles disperser M-401 to Sweco Vibrating Screens.

Operation: This air operated non-lubricated double diaphragm pump is used to transfer reclaimed solids slurry to Sweco vibrating screens. The pump is 1.5 inch (38 mm) in size.

7. Sweco Screens S-401 (glaze), S-402 (slip)

Function: To screen solids slurry.

Operation: The SWECO screens are 762 mm in size and are equipped with 0.5 HP (0.37 kW) motors. The screen produces a homogenized output slurry by removing oversized solids particles in the influent slurry.

8. Magnetic Separators A-401, A-402, A-403, A-404

Function: To remove ferrous based contaminants.

Operation: The four magnetic separators are of the Permanent Magnet type. A-401 is 100 mm in size, while the other three separators are 50 mm in size. The magnets remove the undesirable ferrous based impurities and prevent them from being recycled or reused.

9. Glaze Storage Tanks T-402, T-403, T-404, T-405

Function: To store reclaimed, screened glaze material.

Operation: The screened glaze slurry is transferred into these holding tanks to await QA/QC testing and inspection. T-402 is designated for the white glaze

slurry. This tank is approximately 7 m^3 in volume. The other three tanks are designated for bone (T-403), gray (T-404), and mixed glaze colours (T-405) and are also 7 m^3 in volume. All four tanks are made of fibreglass reinforced plastic (FRP).

10. Slip Storage Tanks T-406, T-407

Function: To store reclaimed slip slurry.

Operation: The screened slip slurry is transferred to storage tanks T-406 and T-407. T-406 is used for holding polymer added slip. T-407 is used for storing virgin slip. Tank T-406 is made of FRP and is 7 m^3 in volume. Tank T-407 is made of 304-SS and is 16.7 m^3 in volume.

11. Mixers M-402 to M-407

Function: To maintain a homogeneous mixture.

Operation: The six low speed (40 rpm) mixers are installed in Storage tanks T-402 to T-407. All mixers are equipped with 7.5 HP motors except for M-407 (15 HP motor).

The mixers are equipped with dual flat paddle type impellers and are used to prevent the solids from settling out and to maintain a homogeneous mixture while awaiting QA/QC testing results.

2.7 SYSTEM OPERATION

Operation of individual unit processes were discussed in Subsections 2.5 and 2.6 above.

Section 3.0

PROJECT IMPLEMENTATION

Even though the original project objectives, including the environmental and economic goals, have been achieved to a reasonable degree, certain problems have arisen during the implementation stage. Some delays in construction as well as difficulties in the wastewater treatment and solids recovery and recycle system startup have been experienced. For this reason, the target capital works completion date of December 31, 1990, was not met. The problems are outlined below.

3.1 CONSTRUCTION AND EQUIPMENT INSTALLATION

PROBLEMS DURING CONSTRUCTION

The problems that were faced during the construction were mainly related to the following factors:

1. Difficulties in coordinating construction activities with the ongoing daily production schedules.

2. Difficulties in accessing and utilizing the existing building to house all required equipment.

3.2 COMMISSIONING AND STARTUP

PROBLEMS WITH WASTEWATER TREATMENT AND SOLIDS RECOVERY AND RECYCLE SYSTEM

The following is a list of problems experienced during the wastewater treatment and solids recovery system startup:

1. Considerable delays when the recycle system was connected to the existing automated batch production system.

2. Delays in the startup of the solids recycle system.

3. Synchronization of the recovered solids recycling activities with the current production steps.

4. Cross contamination of the colours of the recovered glaze material.

5. Abrasion of the submersible mixer components (i.e. propellers) and their subsequent replacement with more resistant construction materials.

6. Excessive settlement and subsequent development of dead zones in the storage and settling tanks.

7. Minor operational problems with chemical feed systems.

8. Lesser degree of success with the slip recycle.

Section 4.0

PROJECT EVALUATION

Technically, the overall materials recovery system and most components of the treatment and recycle systems, including the Lamella clarifiers, the filter press, and the pumps, have been quite reliable. The exceptions have been the problems associated with the submersible mixer propeller abrasion and some minor operational difficulties experienced with the chemical addition systems. Overall, the system has been reliable in wastewater treatment and solids recovery operations and the contractors, equipment suppliers, and engineering consultants, with assistance from American-Standard technical staff, have been effective in mitigating residual implementation and operational problems.

4.1 ENVIRONMENTAL GAINS

The waste management system constructed and implemented by American-Standard and funded in part by MOE's 3Rs program has been partially successful in achieving the original goals which were presented in American-Standard's 1989 proposal to MOE. American-Standard's two major solid waste streams (slip material and glaze material) have been segregated and these two materials are recovered in fairly complex wastewater treatment and solids recovery and handling systems. In this manner, reusable resources, which would have been otherwise wasted, are recovered and reused as raw materials in the manufacturing process.

The waste management system has resulted in considerable reduction in sludge volumes and the associated sludge haulage and disposal requirements. These factors have led to corresponding reductions in the loading on Metro Toronto's already over-stressed landfill sites. Implementation of the inhouse sludge dewatering and recycle program has meant that reduced sludge volumes leave the plant boundaries, thereby reducing any concerns for their potential environmental impact.

4.2 DEVIATIONS FROM ORIGINAL PLANS

A number of minor changes to the original process was made during the system implementation. The main deviations from our original plans are listed below:

- Use of a reversible screw conveyor instead of a conventional, one directional conveyor
- Addition of magnetic separators, and Sweco screens
- Use of Cowles disperser instead of the originally proposed paddle mill

These changes were made to facilitate recycle and reuse operations.

4.3 COMPARISON BETWEEN ESTIMATED AND ACTUAL RECYCLE RATES

GLAZE SOLIDS

The original estimate of 12 tons of recovered glaze per week has not been realized. However, to date, some success has been achieved in the recovery and reuse of the glaze waste stream. In 1991, over seventy tons of glaze material was recycled (see Table 3). The highest monthly total occurred in July when 20.4 tons (Appendix F) of this material was reused. Increased recovery and reuse of the glaze material is expected with time as the recycling activities are synchronized more effectively with the plant production steps.

Table 3
Reported 1991 Glaze Recycle

Month	Quantity Recycled (tons)
May	2.3
June	16.2
July	20.4
November	32.5
Total	**71.4**

SLIP SOLIDS

Recycle of the slip material has not been realized (estimated full recycle was approximately 20 ton/wk). The underlying problem is the use of chemical flocculants and polymers in the solids settling stage (see Appendix F. July 12. 1991 memorandum for further details). These polymers and the chemical conditioning processes render the recovered solids unsuitable for recycle and reuse in the manufacturing process. However, the solids recovered in the settling clarifiers are filter pressed for volume reduction. And with the recent MOE Classification of this material as "Inert Fill", the slip material is being sent offsite to be used entirely for finished products in other manufacturing operations.

Even though to date, the potential of the recycle system has not been realized, in order to reuse the recovered materials onsite (to the originally estimated quantities). American-Standard is actively researching ways of slip and glaze materials recovery without the use of flocculants that inhibit their reuse as resource materials (Appendix F, July 12, 1991, memorandum). In the meantime, arrangements have been made with local manufacturing companies willing to accept American-Standard's recovered clay at considerable savings to American-Standard.

4.4 COMPARISON BETWEEN ESTIMATED AND ACTUAL COST SAVINGS

The original estimate of savings from the glaze material recycle was $565,000. The solids recovery and recycle system, even though its potential has not been fully realized, has been an economic asset to American-Standard. Approximately seventy tons of glaze material was recovered in 1991. This amounts to annual materials savings of up to $70,000. The total savings including the eliminated landfilling costs is approximately $90,000 for the glaze material.

The recent "Inert Fill" classification of the slip material and its on and offsite reuse could translate into annual savings of up to $130,000. Therefore, the estimated annual savings from this waste management system is over $210,000. This figure is expected to rise with the anticipated improvements to the recovery and recycle protocols and procedures.

The consultants' and contractor's estimates and quotes have been reasonably accurate. Any additional costs and reduced revenue from materials recovery and recycle have been related to the startup and implementation problems outlined above. The savings are expected to rise with the anticipated changes to the recycle procedures.

4.5 DOs AND DON'Ts

Based on experience of this project the following suggestions are made.

- Prior full-scale research and development should be carried out to ensure that chemical conditioning agents and polymers used in solids recovery are compatible with final product QA/QC Standards.
- Dosage and type of polymer should be optimized to match the production specifications.
- If possible, new buildings should be constructed in favour of the less costly, but more difficult option of retrofitting existing buildings to house a fairly large and complex wastewater treatment and solids recovery and recycle system.

Section 5.0

CONCLUSIONS

Some problems in the implementation stage were experienced. However, to date, based on the success of this project in recovery and reuse of solid waste materials, in our opinion the waste management project has been a fairly successful undertaking.

A major portion of the glaze waste stream may be potentially eliminated from landfill disposal, and some recycle and reuse of the suitable recovered material has been realized to date. The recovered slip material has been classified as "Inert Fill" and is proven to be a marketable commodity. It is American-Standard's intention to salvage more glaze and slip material without the use of chemicals, which will make the recovered materials more suitable for onsite reuse.

Appendix F

REPORTED RECYCLE DATA

Date: July 12, 1991

Subject: Recycling Program for Slip and Glaze Material for May and June, 199

From: J. C. Lowe

To: R. P. Eaboni

cc: B. Ferguson

D. Baboolal

As discussed, we have been retrieving and recycling the materials from plant effluent and have distributed them as follows.

Glaze

	Material Retrieved for Recycling	Material Recycled	In Storage	Disposed	Tota
MAY					
White	2,303 Kgs	2,303 Kgs	0 q	N/A	N
Other Glaze	N/A	N/A	N/A	N/A	N/
Polymer Slip	N/A	N/A	N/A	N/A	N/
JUNE					
White	11,208 Kgs	11,208 Kgs	0	5,292 Kgs	16,500
Other Glaze	9,169 Kgs	5,000 Kgs	4,169 Kgs	26,111 Kgs	35,280
Polymer Slip	7,303 Kgs	303 Kgs	7,000 Kgs	36,917 Kgs	44,220

N.B.: Material disposal figures supplied as presses disposed of - all oth are from slip and glaze processing.

As can be seen, we have not realized the savings from all of the materials th are to be recycled.

The following explains our current situation and gives some reasons for the differences.

We are successful in recycling all of the white glaze and since the middle of June, are able to use a large portion of the other glaze back into glaze inst of going back into the slip. This is not practical due to the high levels of polymer used in the process which were not envisaged.

A major concern is the ratio of other glaze to white glaze. This bears no relationship to the amounts of glaze used in production, an investigation into the process indicates that white glaze is going to the other glaze. Measures now being taken to correct this situation.

Further studies have been taken of the "mass balance" at the spray machine, an give the following.

Mass Balance

	CH2M Hill Study	American Standard Study	American Standard St
	#2 Machine 06/19/90	#1 Machine 06/12/91	#2 Machine 07/11/91
Glaze on ware	43.9%	46.7%	53.4%
Glaze as direct reclaim	18.1%	42.0%	31.0%
Glaze to waste treatment system	38.0%*	5.7%	14.5%
Balance unaccounted for		5.6%	1.1%

* Amount determined by difference between the totals of glaze on ware and glaz as direct reclaim.

Although the percentage of glaze to the waste treatment system is lower that t percentages found on 06/19/90, the tonnages or presses of glaze completed by t waste treatment people, are relatively close to the 40 tons per month reported potential savings.

Slip

As is seen, the press people report 44 tons as being disposed of. This is low than the 100 tons per month anticipated, but works in our favour.

The design was to produce 75% of slip without polymer addition and 25% polymer treated. It has been found that polymer must be used for all slip processing in higher volumes that we planned for. The polymers are very detrimental to casting slip qualities and also produces a polymer treated slurry that has a v low percentage of solids.

The polymers make the slurry of a nature that we can only use it in solid cast slip (tank slip) at this time. Unfortunately, the low solids content does not allow it to be used in tank slip without somehow adding more solids. Product experiments of adding loss clay pieces from the finishing and spray operation the slurry have raised the solids content. This, in conjunction with lowerin tank slip Specific Gravity from 1.86 to 1.85, will allow us to use approximat 20 tons per month of the polymer treated slip.

If we are to add the clay loss as material to the polymer slip slurry, we mus
provide equipment to the system to allow this to be done on a production basi
Further trials are required before we determine if this is the correct course
action to be taken.

We have also requested that local pottery/ceramic supply companies look at wa
of using the clay scrap in manufacturing processes and anticipate replies to
requests before the end of July.

It is also considered that we must find ways of reducing the amounts of polym
used and or eliminate its use in treatment of slip as was the original intent

J. C. Lowe
JCL/nh

Inter-Office Memo

American Standard

Date: August 6, 1991

Subject: Update on Waste Treatment and Recycling of Slip and Glaze Material for July, 1991

From: J. C. Lowe

To: R. P. Baboni

cc: B. Ferguson
D. Baboolal
K. Badan

GLAZE

Colour	Material Retrieved Kgs	Material Recycled Kgs	Material Disposed Kgs	Material Placed In Kgs	Total Material in Storage Kgs
White	9,950	6,350	0	3,600	3,600
Others	30,450	13,993	9,926	6,531	10,700

SLIP

Polymer Only	80,000	0	80,000	0	7,000

N.B. Figures derived from the attached information supplied by Kris Badan and Don Baboolal (see attached). The amounts of material disposed of are arrived at by subtracting the amounts recycled and stored from the total amounts retrieved.

Comments

The July figures for glaze include the cross contamination of Bone and White into others. However, we can recycle this at a ratio of 1:1 into white glaze with some minor adjustments.

The large amount of other glaze disposed of are probably due to general clean-u of glaze systems carried out during shutdown.

During July, we have confirmation of the 40 tons of glaze per month that is available for recycling.

With the slip, we have found a means of adding dry clay scrap (from the proc clay loss) that utilizes existing systems. This is a labour intensive metho but will allow us to recycle some polymer treated slip without any further capital outlay. Presently, the Maintenance Department are cleaning and repairing the buckets elevators located in the slip house which are required this process.

Methods of de-watering slip without polymers have not been possible to date. Barry Ferguson has contacted various equipment suppliers regarding the feasibility of doing this and hopefully shall have some favourable news in t near future.

John

J. C. Lowe

JCL/nh

AMERICAN STANDARD

INTER-OFFICE MEMO

Date: November 7, 1991

Subject: WASTE TREATMENT AND RE-CYCLING OF SLIP AND GLAZE MATERIALS - SEPTEMBER AND OCTOBER

From: J. C. Lowe

To: R. P. Eaboni
D. Baboolal
J. Ng
K. Badan
B. Ferguson
K. McLenahan

Glaze Colour	Material Retrieved Kgs	Material Recycled Kgs	Material Disposed	Material Placed In Storage	Total Material In Storage
White	11,190	9,800	1,390	0	0
Bone	9,950	8,500	1,450	0	0
Other	40,500	14,200	26,300	0	0
Slip	58,500	0	58,500	0	0

Due to high polymer usage, we have disposed of all materials in storage. This system has been re-started in November with strict instructions to use minimum and controlled amounts of polymer.

J. C. Lowe
JCL/nh